OPTIMISATION OF SCRAM JET STRUT INJECTION

Department of Mechanical Engineering

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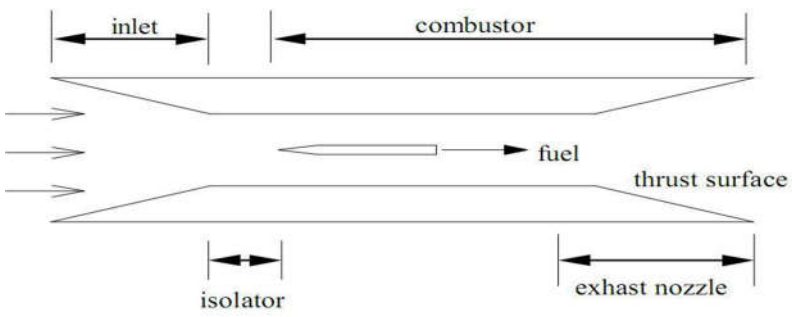
Abstract - The Scramjet engine design is an extension of the Ramjet. However a Scramjet allows the flow through the engine to remain supersonic, whereas in a Ramjet the flow is slowed to subsonic levels before it enters the combustor. The main problem of scramjet fuel injection is that the airflow is quite fast, meaning that there is minimal time for the fuel to mix with the air and ignite to produce thrust (essentially milliseconds). In such cases the simulation of a supersonic reactive flow is an important tool for the investigation and development of Scramjet engines. Numerical investigations have become less expensive than experiments. In this project, mixing and combustion for different shaped strut injector's are being analyzed in Ansys Fluent Software.

Key Words – Scramjet Engine, Ramjet Engine, Struts, Strut Injection, Supersonic Combustion, Ansys.

1. Introduction

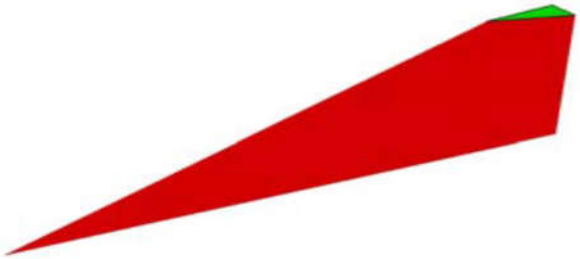
In the History of the supersonic combustion there are two types of systems which is defined and operated in the high velocity regimes Scram jet and ram jet where ram jet sometimes refereed as the Flying Stove an air breathing engine which supports the air intake of forward motion to compress incoming air and support the sub sonic flight systems however the advantage with this type of system is more but when we are using the Ramjet in the system it can only operate at high velocities of system movement it cannot start an engine with the zero velocity condition or stand still therefore ramjet systems need an assisted takeoff that means it need an assisted pushing system like a rocket to pus to the high velocities. However it can work at high velocity speeds at Mach 3 and Mach 6

The Scramjet engines can be viewed as a type of ramjet engine whereas when it comes to ramjet the incoming air decelerates before combustion in ramjet systems where in the scramjet the velocity if the air is same throughout the systems. The incoming air which is supersonic is same throughout the engine. The Scramjet consists of 4 major parts: the inlet, isolator, combustor and exhaust nozzle

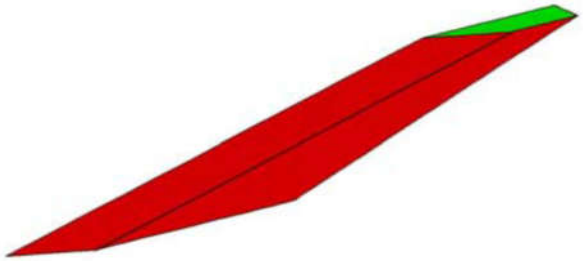


2. LITERATURE REVIEW

[1] **Dr. Krishna Murari Pandey & Thangavel Sivashakthivel** chipped away at a theme named "Ongoing Advances in Scramjet Fuel Injection - A Review", in which they found out that– Fuel injection process in to scramjet motors is an area of prominent growth. A scramjet engines uses either gas or fluid. The air fuel mixture should be thoroughly mixed to around stoichiometric extents for proficient combustion to occur. The fundamental issue of scramjet fuel infusion is that the airflow is very quick, implying that there is insignificant time for the fuel to blend with the air and touch off to deliver push (basically milliseconds).Hydrogen is the primary fuel utilized for combustion. Hydrocarbons present even more a test contrasted with hydrogen because of the more drawn out start delay and the prerequisite for further developed blending procedures. Upgrading the blending, and in this manner diminishing the combustor length, is a significant angle in planning scramjet motors. There are number of strategies utilized today for fuel infusion into scramjet motors.[2] **K.M.Pandey and T.Sivasakthivel** chipped away at a theme named "CFD Analysis of Mixing and Combustion of a Scramjet Combustor with a Planer Strut Injector". The two-dimensional coupled implicit NS equations, the standard k-ε turbulence model and the finite-rate/eddy-dissipation reaction model have been applied to numerically simulate the flow field of the hydrogen fueled scramjet combustor with a planer strut flame holder under two different working conditions, namely, cold flow and engine ignition.[3] **Yuan shengxue** took a shot at the point "supersonic combustion", in which he found that – The estimation of combustion in supersonic flow demonstrates about entropic increase & all out loss of weight in flame items might diminish alongside the expansion of burning speed. The diagonal explosion ripple edge wouldn't get constrained by wedge point lower frail & driven arrangement circumstances & be resolved distinctly by combustion speed.[4] **Gruineg and F. Mayingar** took a shot about "Supersonic combustion of lamp fuel/h2-blends in a prototype Scramjet combustor", in which they found out that– an important temperature level is somewhat accomplished by the angled shock ripples in the supersonic flow alongside expanding combustion zone proportion. [5] **K.Kumaran and V.Babu** took a shot at the subject of "Examination about certain impact of science representations on the arithmetical expectations of the supersonic combustion of H2", in which they found out that– Multi step science foresees bigger & more extensive layout warmth discharge more of what is anticipated by one step science. The one step science representation is equipped for anticipating general execution boundaries by the help of significantly low computation expense. A superior tradeoff b/w push expansion & combustion effectiveness shall be accomplished with the help of organized combustion.



Conceptual view of Strut (A)



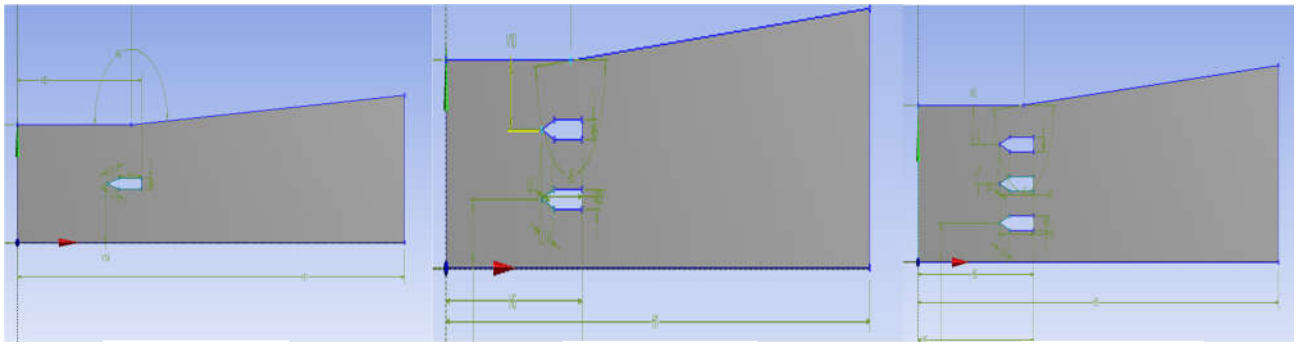
Conceptual view of Strut (E)

PROCEDURE:

In this experiment, the **density of the air fuel mixture** (i.e. air and hydrogen), **Mach number** and **static pressure** inside the scram jet engine's combustion chamber are analyzed with the help of Ansys Fluent Software. The base paper for the project have been taken from one of the K.M Pandey's contribution to the field of scram jet engine technology **"CFD Analysis of a Hydrogen Fueled Mixture in Scramjet Combustor with a Strut Injector by Using Fluent Software"** and few other papers of him. Below is the description of how the experiment is beingcarried out in the environment of Ansys Fluent Software.

i) **Geometry**:

A simplified combustion chamber is created in the geometry section of the software provided with two types of struts, one being the triangular strut {strut A} and the other is the experimental strut named {strut E}. The above mentioned struts are also categorized into three types based on their configuration in the combustion chamber,



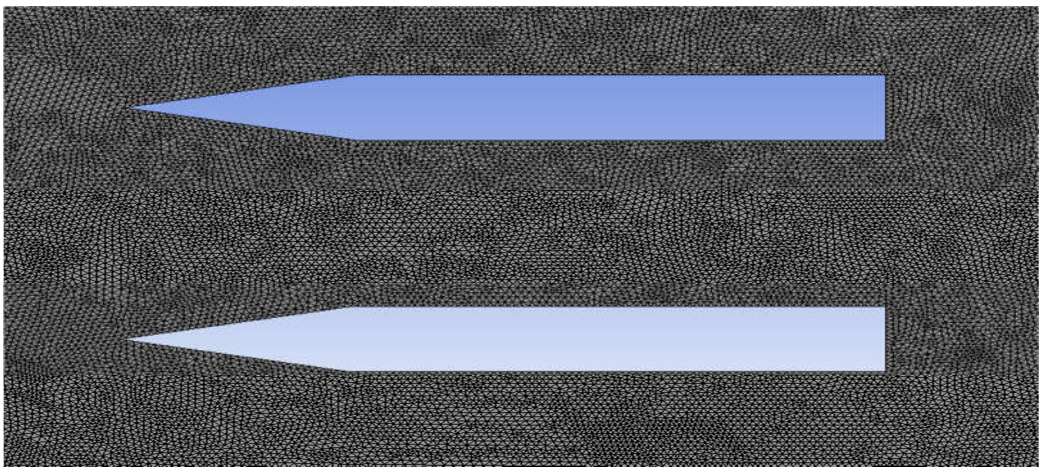
Single strut Double strut Triple strut

Meshing:

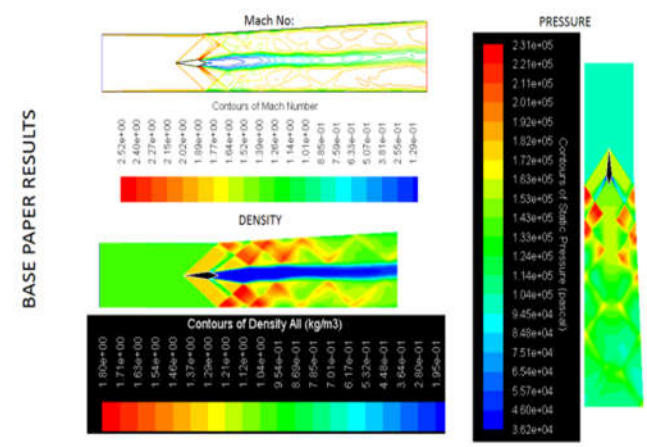
Later, the model is meshed in the meshing section. We have emphasized the strut boundaries to have higher mesh density in the combustion chamber in order to obtain the results more precisely. Such that the changes in the pressure, density and in Mach number around the strut to be more clearly observable.

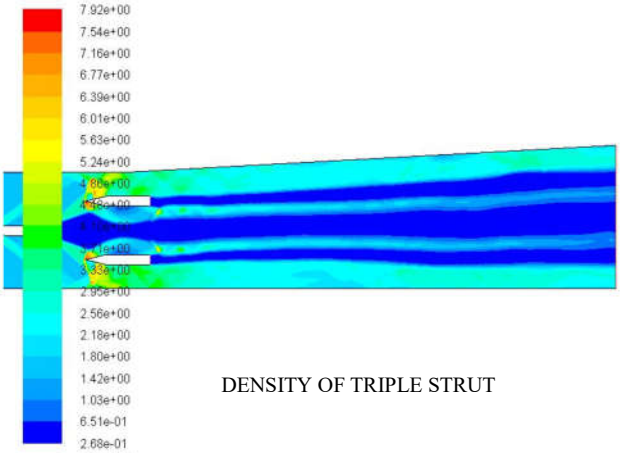
Higher mesh density + less element size = Better results

a) Face size - 0.30mm b) Element size - 0.60mm c) Total elements – 433111

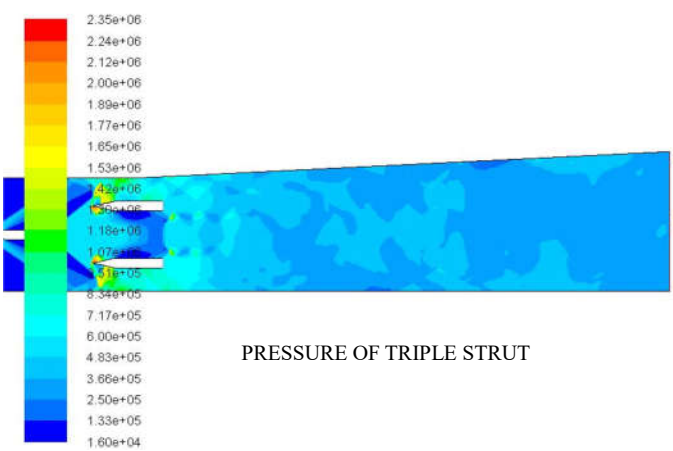


RESULTS:

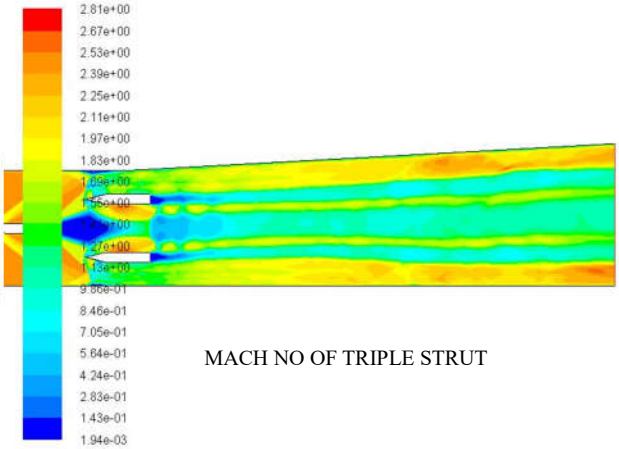




DENSITY OF TRIPLE STRUT



PRESSURE OF TRIPLE STRUT



MACH NO OF TRIPLE STRUT

OVERALL RESULTS IN TABULAR FORM

PAPER	DENSITY of Strut A	Density Of Strut E	Mach No of Strut A	Mach no Of Strut E	Static Pressure of Strut A	S Pressure of Strut E
BASE PAPER 1	1.80	--	2.52	--	2.31	--
BASE PAPER 2	1.89	--	2.17	--	2.61	--
Experimental Single strut	2.55	3.45	2.55	2.98	4.38	7.01
Experimental Double strut	4.87	4.59	2.56	2.56	1.01	1.02
Experimental Triple Strut	7.09	7.92	2.57	2.81	1.98	2.35

The provided images of result are of Density, Pressure and Mach no for the Triple Strut E Configuration compared against the results of the base papers.

5. Conclusion:

In above investigation the k-w model is used to inspect the mixing in a scramjet model under realistic operating conditions. The configuration used is alike the scramjet engine in the lab where its development and experimentation took place at (Deutsches Zentrum für Luft- und Raumfahrt) Germany. The Configurations in this computational work is made for single double and triple strut is made to employ the behavior and improvement of increasing struts in the combustion chamber to see this change the current work is very helpful in visualizing and comparing the existing and newly employed turbulence model for single double and triple strut injection systems in the scram jet combustion chamber after thorough simulation the completed and compared results with each other there is a significant mixing and improvement in shock wave generation is observed in triple strut model therefore there is more room for improvement in this are due to space constraint we can't go more than three struts unless new arrangements are introduced in the current work the highly performed configuration is Triple Strut E model.

References:

[1] **Dr. Krishna Murari Pandey and T.Sivasakthivel**, "Recent Advances in Scramjet Fuel Injection - A Review," International Journal of Chemical Engineering and Applications vol. 1, no. 4, pp. 294-301, 2010.

[2] **Dr. KM Pandey and T.Sivasakthivel**, "CFD Analysis of Mixing and Combustion of a Scramjet Combustor with a Planer Strut Injector" *Vol. 2, No. 2, April 2011*

[3] **yuan Shengxue,** "supersonic combustion", vol. 42, no. 2, science in china (Series A), February 1999,

[4] **Gruenig and f. Mayinger,** "supersonic combustion of erosene/h2-mixtures in a model scramjet combustor", institute for thermodynamics, technical university Munich, and d-85747.

[5] **K. Kumaran and V. Babu,** "Investigation of the effect of chemistry models on the numerical predictions of the supersonic combustion of hydrogen", Combustion and Flame, vol 156, 2009, pp.826–841.